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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :
H04L 25/14

A1

(11) International Publication Number: WO 90/12467

(43) International Publication Date: 18 October 1990 (18.10.90

(21) International Application Number: PCT/DK90/00087

(22) International Filing Date: 6 April 1990 (06.04.90)

(30) Priority data:
1675/89 7 April 1989 (07.04.89) DK

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(81) Designated States: AT (European patent), AU, BE (European patent), BG, BR, CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GB (European patent), HU, IT (European patent), JP, KP, KR, LU (European patent), NL (European patent), NO, RO, SE (European patent), SU, US.

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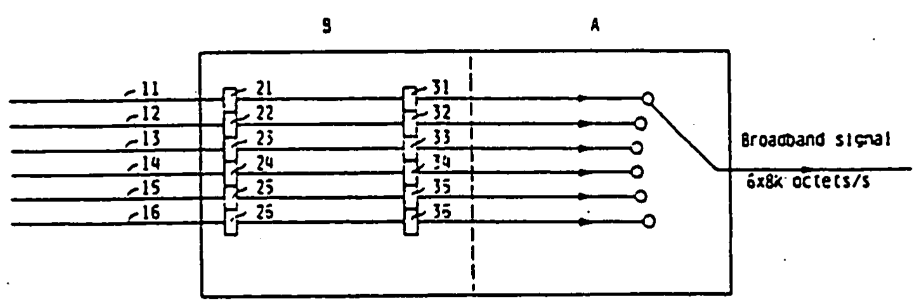
With international search report.

(54) Title: A METHOD IN THE TRANSMISSION OF A DIGITAL BROADBAND SIGNAL



(57) Abstract

A digital broadband signal is divided into a plurality of subsignals by demultiplexing, each of said subsignals having a lower bit rate than the broadband signal and being distributed on and transmitted along its respective subchannel (11-16) like e.g ordinary digital telephone channels having arbitrary propagation times. The differences in propagation time is compensated by transmitting at least one flag on each subchannel at start and by individually delaying the received signals in the receiver in response to the received flags, so that the broadband signal can be reestablished from the subsignals by multiplexing. No return signal path is needed in this automatic start, and the least possible delay is inserted to permit the broadband signal to be reestablished in operation.

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A method in the transmission of a digital broadband signal

The invention concerns a method in the transmission of a digital broadband signal from a transmitter to a receiver via a plurality of digital subchannels having arbitrary propagation times, and as stated in the introductory portion of claim 1.

The US Patent Specification 4 775 987 discloses a digital transmission system which performs such a method, but it does not completely teach how the differences in the propagation times of the subchannels are compensated.

The invention is particularly useful in connection with transmission via the public telephone network, but, as appears from the following, it can also be used in other connections where the bit rate of the available transmission channels is insufficient for transmission of a broadband signal.

The public network includes 64 kbits/s transmission channels which are e.g. used for digital telephony. When the bit rate of a telephone channel is smaller than the bit rate of the signal (here called the broadband signal) to be transmitted, the broadband signal can be divided into a plurality of signals by means of known multiplex technique, each of said signals having a lower bit rate than the broadband signal. These signals will be called subsignals, which can be transmitted between transmitter and receiver on their respective subchannels via the telephone network. For the broadband signal to be reestablished from the subsignals it is necessary that these have the same transmission time through the respective subchannels. This can be obtained by manually hard wiring the necessary number of subchannels in the transmission net-

work, it being ensured that the individual channels follow the same trunk group through the network. An example of this method is leased 2 Mbits/s connections. This work is expensive and time-consuming, because the necessary number of subchannels often has to be ordered long before they are to be used, just as the manual wiring is time-consuming.

The object of the invention is to provide a method enabling the use of a plurality of arbitrary, not specially set-up subchannels for multiplex transmission of broadband signals.

This object is achieved in that the method is performed as stated in the characterizing portion of claim 1 or 2. In case of transmission through subchannels having arbitrary propagation times e.g. a telephone subscriber himself can call the necessary number of telephone connections, without it being necessary to take into account how the telephone connections are physically set up separately. For digital multiplex transmission it is desirable to use generally available 64 kbits/s digital telephone channels as subchannels. The telephone channels are set up in the telephone network through arbitrary trunk groups, which may have different transmission times, and which will typically all be loaded by telephone conversations already established. In the method of the invention it is no longer necessary to demand that the individual subchannels shall be established through one and the same trunk group; it can be entirely left to the telephone exchange to establish the individual subconnections, thereby establishing an inexpensive broadband connection rapidly. It is also obtained that the probability of rejection is reduced drastically. Only hereby is use made possible in practice.

In addition to the usual 64 kbits/s public telephone channels there are also a few public 2 Mbits/s channels in a dedicated network, which can e.g. be used for video transmission. It will be appreciated that the method of the invention can also combine several such 2 Mbits/s signals for transmission of e.g. an 8 Mbits broadband signal by means of four such channels. It is also possible to combine a plurality of 64 kbits/s channels and a plurality of 2 Mbits/s channels.

A further use of the invention is in connection of radio transmission of a 64 kbits/s connection, where a 64 kbits/s signal is now perceived as the broadband signal, which is divided into 8 radio channels of 8 kbits/s each.

The method of the invention does not require feedback and is therefore useful for point-to-multipoint transmission. Further, the method can be used modularly so that output signals from one or more devices may be used as input signals for another device.

Performance of the method as stated in claim 1 or 2 results in two different expedient start procedures, where the method stated in claim 1 gives the minimum delays which are sufficient in operation to compensate for differences between the propagation times.

When the start phase is over, reading-out can take place cyclically by methods according to claims 1 and 2, in contrast to the method stated in claim 3 where the time delays are established by switching the sequence in which the subsignals are received.

Additional signal processing may be desired for some uses before the broadband signal is transmitted further on from the receiver, and in such situations it is expedient to

provide for an additional time delay of the received signals, as appears from the method in claim 4.

It is to be ensured in connection with a start sequence that correct connection is established, which traditionally involves feedback from receiver to transmitter. This is inexpedient and even unnecessary in the method of the invention. To improve the certainty of correct start the start sequence is therefore transmitted a plurality of times, as stated in claim 5. When the call sequence is completed, it will preferably be monitered currently that a transmission error does not disturb the mutual scanning sequence of the subchannels, which can be avoided by means of the method stated in claim 6.

Applied expressions defined by their logic function

- A byte consists of n_b bits.
- An octet is a byte consisting of 8 bits.
- A frame consists of n_{fr} bits.
- A flag of length n_f is a characteristic bit sequence of length n_f.
- A FIFO of length n_s consists of a plurality of store locations $l_1,\ldots,ln_s$. The position i is registered at any time for the next input as well as the position o for the next output. At start, a position s is selected, and i:=o:=s. For each output, o is counted 1 forwardly modulo n_s.
- A flow buffer of length n_x is a FIFO of length n_s, where i-o is constantly equal to n_s. Further, output on other positions may also be possible.

Preferred implementations

FIFO:

As a RAM store with n_s store locations. The position i is registered at any time for the next input as well as the position o for the next output. For start, a position s is selected, and i:=o:=s. For each input, i is counted 1 forwardly modulo n_s. For each output, o is counted 1 forwardly n_s.

<u>Flow buffer</u>:

Either as a special case of a FIFO or in the form of a shift register where the information contents are physically moved one store location forwardly for each new pair of (input/output).

The invention will be explained more fully below on the basis of some preferred embodiments, there being used six subchannels between transmitter and receiver, each of which is an ordinary 64 kbits/s digital telephone channel, and with reference to the drawing, in which

fig. 1 shows the functional principle of a transmitter according to the invention,

fig. 2 shows the functional principle of a receiver according to a first embodiment of the invention,

fig. 3 shows the functional principle of a receiver according to a second embodiment of the invention,

fig. 4 shows the principle of start in the receiver in fig. 3,

fig. 5 shows the principle of reestablishing the broadband signal in operation in the receiver in fig. 3,

fig. 6 shows the functional principle of a receiver according to a third embodiment of the receiver,

fig. 7 shows the principle of start in the receiver in fig. 6,

fig. 8 shows the principle of reestablishing the broadband signal in operation in the receiver in fig. 6, and

figs. 9 and 10 illustrate their respective ones of two possible system configurations for transmission of a video signal.

User's broadband signal is here assumed to have a bit rate of 384 kbits/s corresponding to 6 x 8 k octets/s, and this broadband signal is conveyed to part A of the transmitter. Part B of the transmitter receives the 6 x 8 k octets/s, which are divided into individual octets, which are distributed cyclically on the six 8 k octets/s subchannels 11-16.

The transmitter is shown in fig. 1. Part A can send either a start sequence or user's broadband signal to part B.

The start sequence consists of many idle signals followed by a flag per subchannel. When the transmitter is started, the start sequence is transmitted from part A to part B, and immediately following the completion of this sequence, user's broadband signal is transmitted from part A to part B, where it is distributed on the six output subchannels 11-16.

The receiver in fig. 2 comprises a part B and a part A. The six subchannels 11-16 are passed to the part B of the receiver, which has a flag control 21-26 followed by a FIFO 31-36 for each subchannel. The subsignals are con-

veyed from the FIFOs to the part A of the receiver where the broadband signal is reestablished. During start, and after reception of many idle signals which are ignored, each flag control 21-26 receives a flag which is detected and transmitted to the associated FIFO, which has sufficiently many store locations for the receiver to compensate for the differences between the propagation times of the subchannels occurring in practice. Since six flags are transmitted from the transmitter during start, each buffer receives precisely one flag.

It is detected in the part A of the receiver when all FIFOs have flags on the first location. Then cyclical reading-out is effected from the six FIFOs, and after rejection of the six flags the broadband signal is reestablished with broadband bit rate and is transmitted from the receiver.

Since the six subchannels are not necessarily received in proper cyclic order, this may be compensated for in that six flags are transmitted from the transmitter, said flags being specific for their respective subchannels and being used in the receiver for identification of the subchannels 11-16, following which the receiver adjusts its output order according to the subchannels on which the individual flags are received.

To ensure that start in the receiver is performed correctly also in case of bit errors, a plurality of start sequences can be transmitted, each consisting of

- a plurality of reset bytes,
- a plurality of pause bytes,
- a flag per subchannel,
- a plurality of pause bytes,
- a broadband test sequence and

- a plurality of pause bytes.

The receiver tries to recognize flags as soon as at least one reset byte has been recognized. If the broadband test sequence is not recognized, reset is performed upon recognition of at least one reset byte.

In an alternative embodiment of the receiver according to the invention, each subchannel 11-16 can be read out as soon as the following two conditions are satisfied, 1) that the channel in question has one octet next in turn for being read out, and 2) that, apart from the first reading-out attempt, the cyclically preceeding subchannel has been read out. If reading-out is allowed only at specific points of time, reading-out is postponed to the next permitted point of time. After the first cycle in the start phase, where each octet is a flag, reading-out takes place with full broadband bit rate and with the rythm of the transmitter.

Fig. 3 shows a second embodiment of the receiver according to the invention. Each subchannel is here associated with a frame number indicator 41-46. A frame consists of an octet from each of the six subchannels 11-16. The received signals are entered frame by frame in an n frame large flow buffer 50.

During start, each received octet is examined for whether it is a flag, cf. fig. 4. When the first flag is received, a frame counter 51 is initialized to zero. After each received frame, the frame counter 51 is counted one forwardly. When a flag is received on a subchannel 11-16, the frame number indicator 41-46 of this subchannel is set to the actual value of the frame counter 51. This means that the value zero is allocated to the subchannel 11-16 where the first flag was detected. When a flag has been

received on each subchannel, the start is finished.

The addresses where the flags are in the n frame large flow buffer are calculated and stored, cf. fig. 3, on the basis of the channel numbers and the associated frame counter values. n has been selected such that n is greater than the greatest expected difference in delay between two subchannels measured in frame durations. The octets of the subchannels are arranged in the same order in each frame as in the transmitter. The frames are transferred to the flow buffer for one frame of the broadband signal. A frame of the broadband signal is thus reestablished and can be read out. After reading-out of a frame, the next frame is transferred to the flow buffer for one frame.

Figs. 4 and 5 illustrate the conditions in the receiver in fig. 3 during start and operation, respectively. To the left is shown a section of the n frame large flow buffer where each frame contains a byte from each subchannel. The table to the right of the figure indicates from which frame the byte of each subchannel is to be read out, and this is shown by the arrows between the table and the buffer.

Figs. 7 and 8 illustrate the conditions in the third embodiment in the receiver in fig. 6 during start and operation, respectively. It is allowed here that the order of the subchannels is switched during transmission, and six channel-specific flags are transmitted from the transmitter on the basis of which the receiver can identify the subchannels. The advantage is that the receiver autonomously detects the order in which the transmitter has used these channels by using, in addition to a frame counter, a position counter 53 which is reset for each new frame and is counted one forwardly for each position. Here too, a test sequence is transmitted after a flag sequence, as

described before.

It is illustrated in fig. 8 how the delay in the receiver can be minimized if the signals on the six subchannels are not received correctly positioned in the frame. It is shown how the signals are entered in the flow buffer for n frames in the order in which they are received. Reading-out requires the information about the position of the channels in the frame shown in the table. This information is obtained during start, as shown e.g. in fig. 7.

Fig. 8 shows the flags and the octets in the n frame buffer received in the subchannels after the flags immediately after termination of start.

A different method of the present type in transmission via subchannels having arbitrary propagation times might be realized by providing each byte in all subsignals in the transmitter with identification, using certain bits in each byte for this purpose. The received bytes are then to be currently sorted in the receiver before the broadband signal is reestablished. In such a method part of the bit rate of the subchannels is employed for identification, and the bit rate available for transmission of the broadband signal is thus reduced.

Further, a sorting device is needed in the receiver, which, in addition to adding to the costs of the apparatus, increases the delay so much that use in real time is made difficult.

The current sorting moreover necessitates complicated error correction.

No such sorting device is needed in the method according to the invention, and after start the sum of the full

bandwidth of the channels is available.

Call and setting-up of the telephone channels form no part of the invention, but these are assumed to be established prior to performance of the method according to the invention, just as necessary and known interface circuits for the telephone network are assumed to be available. However, two possible configurations are shown in figs. 9 and 10 where the calling procedure can be performed by ordinary telephone devices.

P a t e n t   C l a i m s :

1. A method in the transmission of a digital broadband signal from a transmitter to a receiver via a plurality of digital subchannels having arbitrary propagation times, wherein

- the broadband signal is periodically divided into a plurality of digital subsignals each of which comprises consecutive bit sequences and has a smaller frequency bandwidth than the broadband signal, and which are transmitted via respective subchannels, and

- the differences between the propagation times are automatically compensated by transmitting at least one flag in each subchannel at start, and by individually time delaying the subsignals in the receiver in response to the respective received flags,

- c h a r a c t e r i z e d in that reading of each individual subsignal is initiated as soon as a corresponding flag has been received and the cyclically preceeding subchannel has been read, to reestablish the broadband signal.

2. A method in the transmission of a digital broadband signal from a transmitter to a receiver via a plurality of digital subchannels having arbitrary propagation times, wherein

- the broadband signal is periodically divided into a plurality of digital subsignals, each of which comprises consecutive bit sequences and has a smaller frequency band width than the broadband signal, and which are transmitted via respective subchannels, and

- the differences between the propagation times are automatically compensated by transmitting at least one flag in each subchannel at start, and by individually time delaying the subsignals in the receiver in response to the respective received flags,

c h a r a c t e r i z e d in that reading of the subsignals is initiated as soon as a flag has been received in all subchannels, to reestablish the broadband signal.

3. A method according to claims 1-2, c h a r a c t e r i z e d in that the received subsignals are merged in a shift register before they are time delayed.

4. A method according to claims 1-3, c h a r a c t e r i z e d in that an additional time delay is provided in the receiver in addition to the one necessary to reestablish the broadband signal.

5. A method according to claims 1-4, c h a r a c t e r i z e d in that repeated start sequences are transmitted, each comprising a flag sequence followed by a known broadband test sequence.

6. A method according to claims 1-5, c h a r a c t e r i z e d in that a plurality of control bits having a predetermined sequence is transmitted in each subchannel, and that the receiver detects whether the sequence of control bits is correctly positioned timewise and corrects the mutual time delay between the subchannels in response thereto.

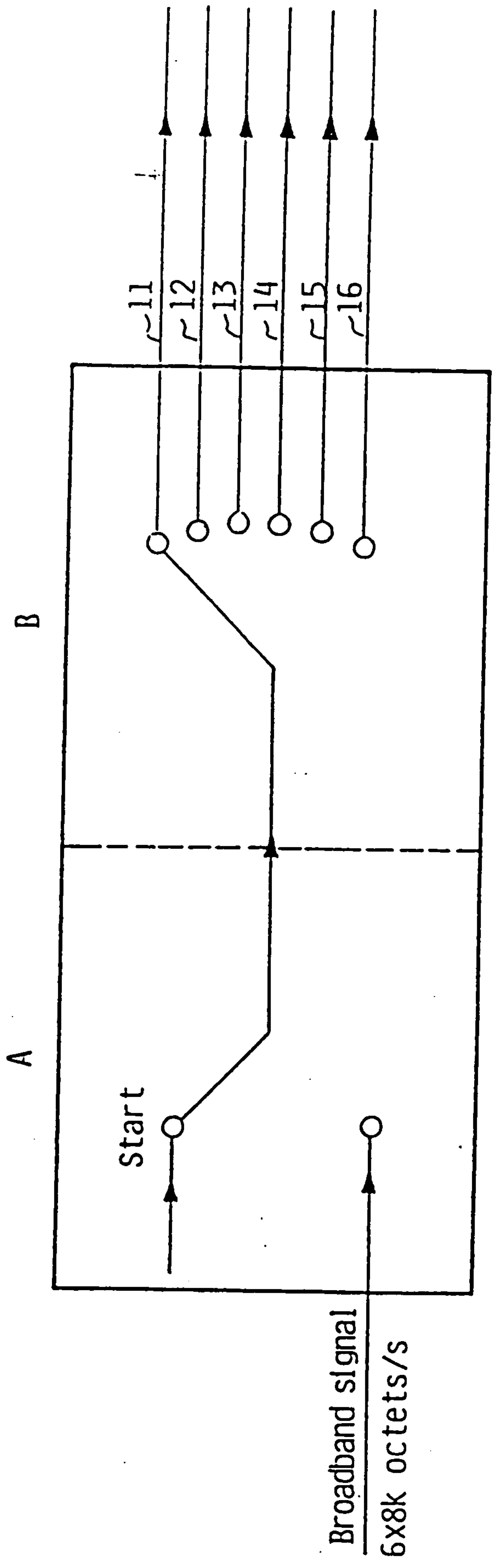


FIG. 1

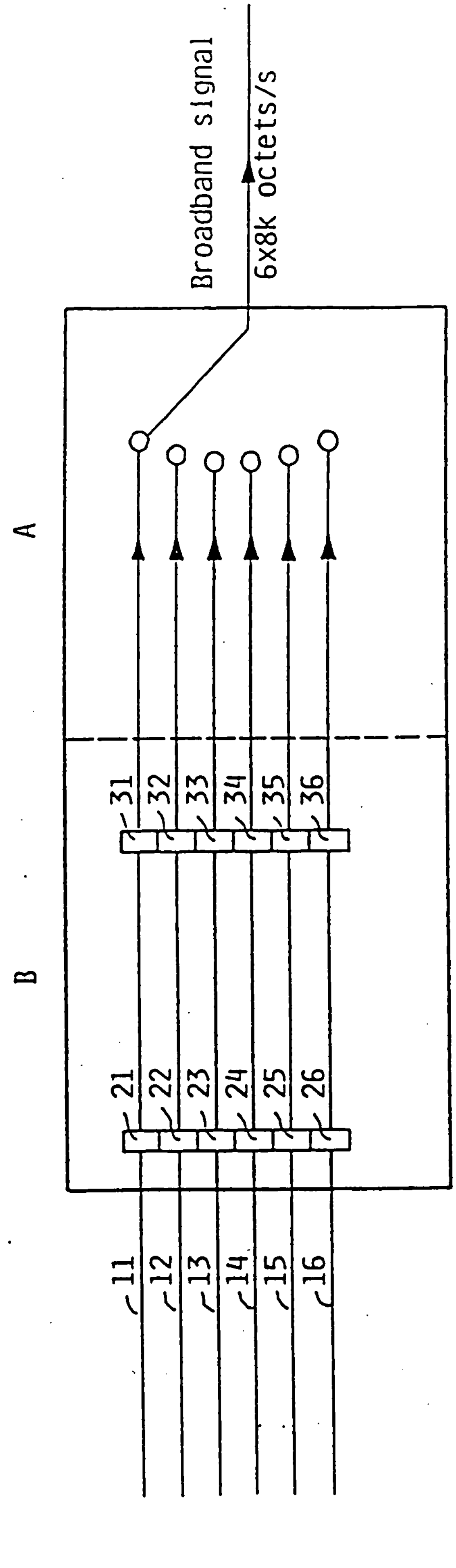

Broadband signal
6x8k octets/s
A
B
31
32
33
34
35
36
21
22
23
24
25
26
11
12
13
14
15
16

FIG. 2

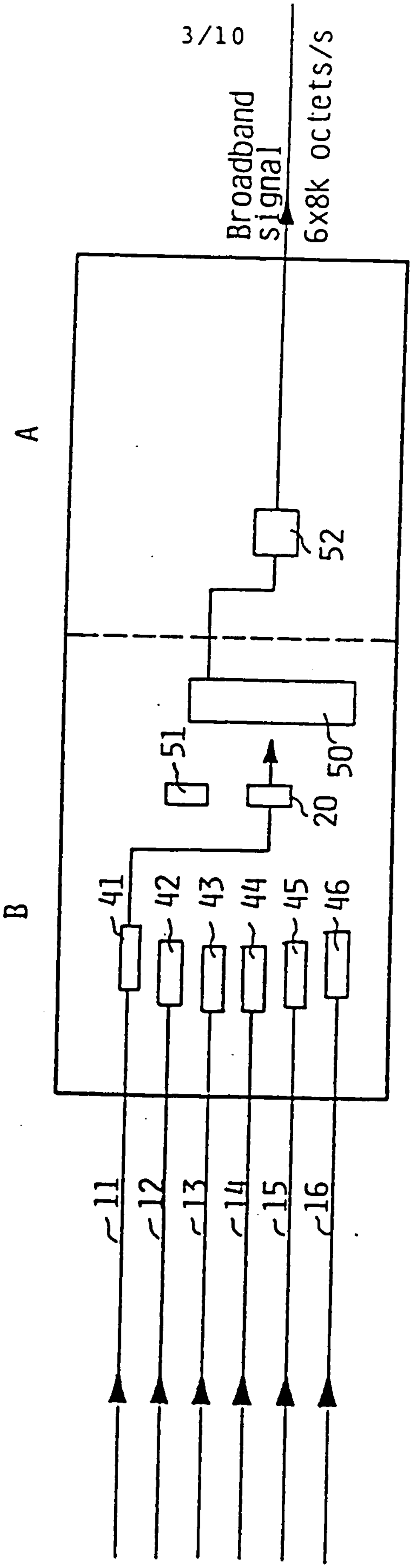
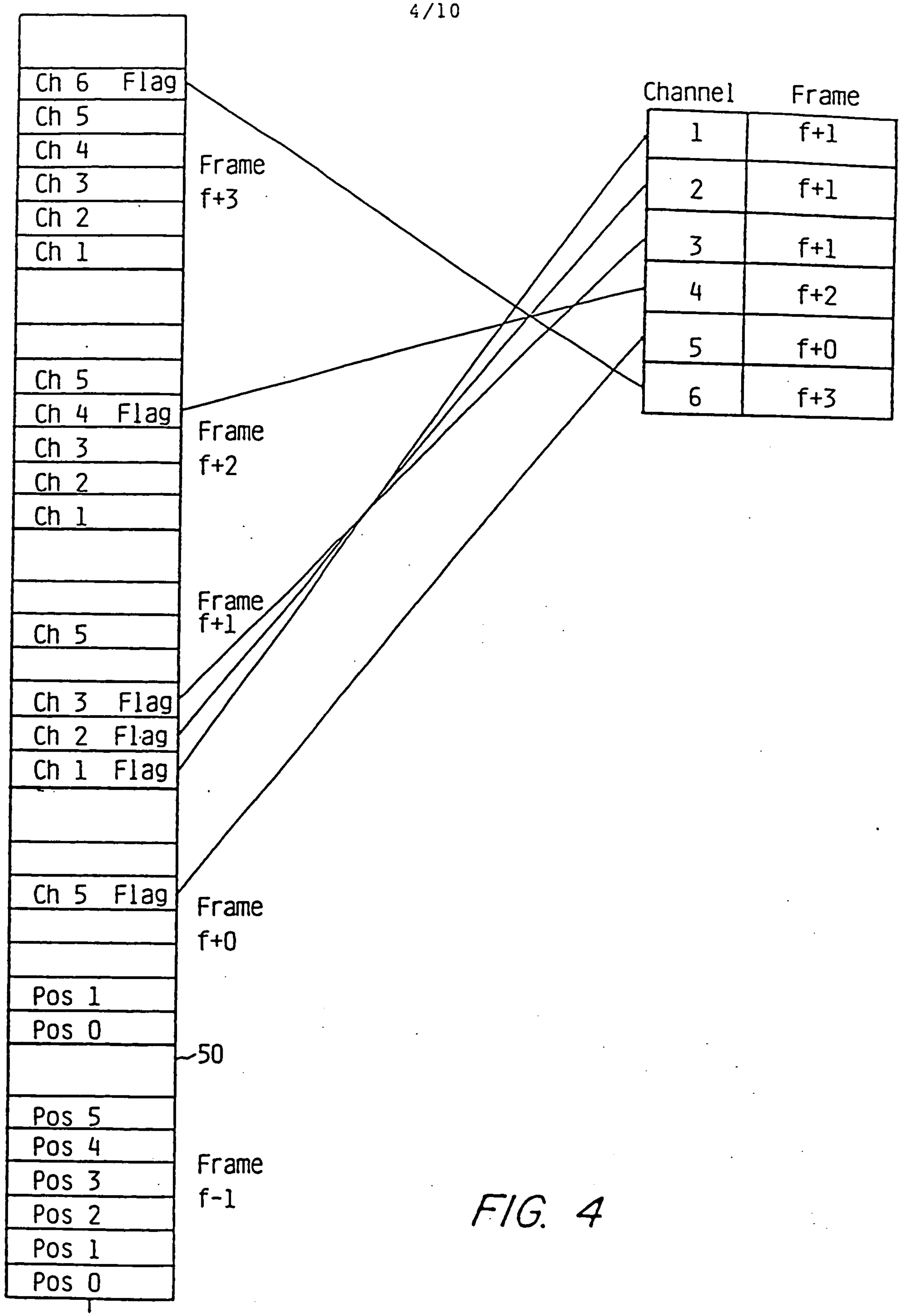
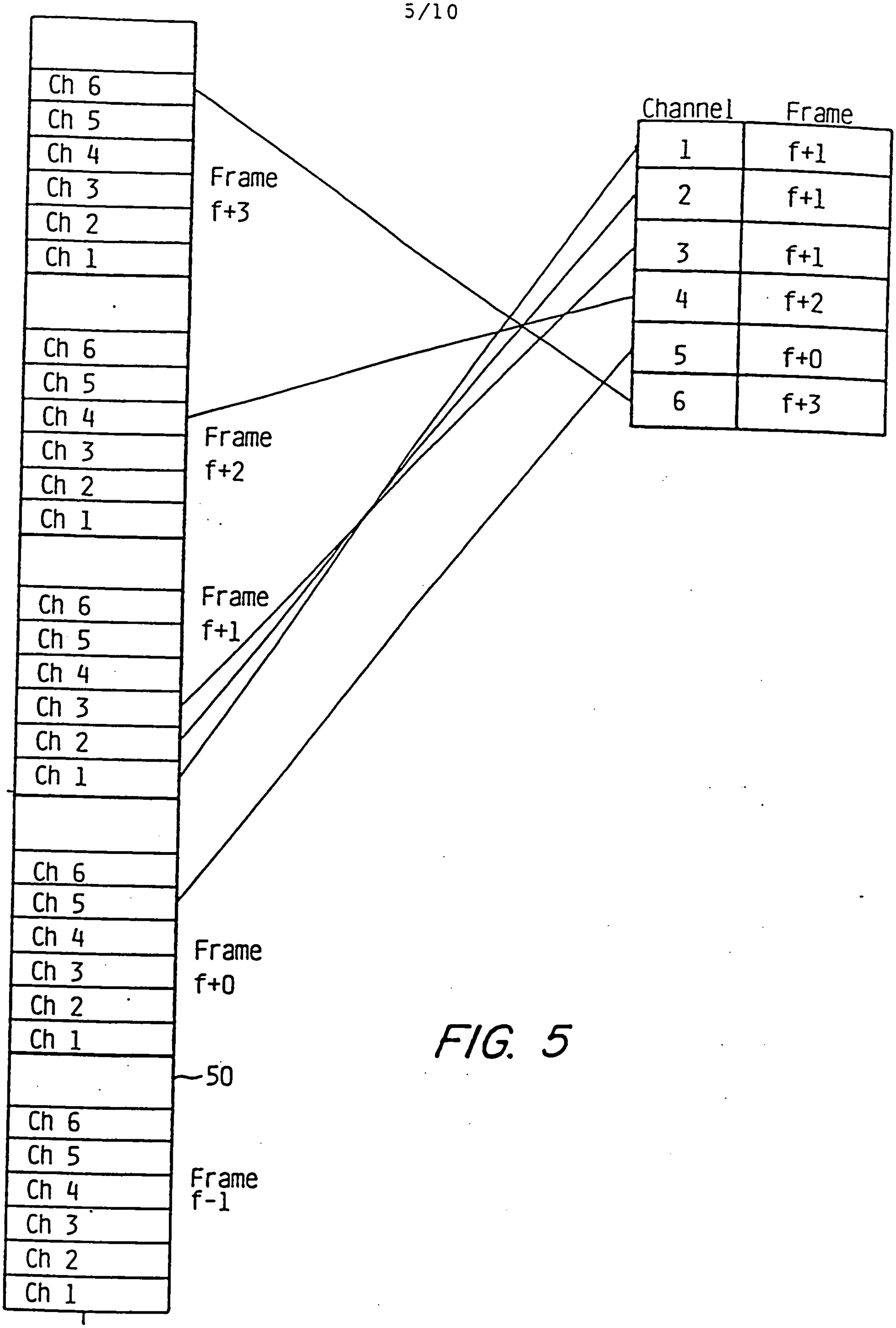

Broadband signal
6x8k octets/s
A
B
52
51
50
20
41
42
43
44
45
46
11
12
13
14
15
16

FIG. 3



Ch 6 Flag
Ch 5
Ch 4
Ch 3
Ch 2
Ch 1
Frame f+3
Ch 5
Ch 4 Flag
Ch 3
Ch 2
Ch 1
Frame f+2
Ch 5
Ch 3 Flag
Ch 2 Flag
Ch 1 Flag
Frame f+1
Ch 5 Flag
Pos 1
Pos 0
Frame f+0
50
Pos 5
Pos 4
Pos 3
Pos 2
Pos 1
Pos 0
Frame f-1
Channel
Frame
1
f+1
2
f+1
3
f+1
4
f+2
5
f+0
6
f+3

FIG. 4


Ch 6
Ch 5
Ch 4
Ch 3
Ch 2
Ch 1
Frame f+3
Ch 6
Ch 5
Ch 4
Ch 3
Ch 2
Ch 1
Frame f+2
Ch 6
Ch 5
Ch 4
Ch 3
Ch 2
Ch 1
Frame f+1
Ch 6
Ch 5
Ch 4
Ch 3
Ch 2
Ch 1
Frame f+0
50
Ch 6
Ch 5
Ch 4
Ch 3
Ch 2
Ch 1
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Channel
Frame
1 f+1
2 f+1
3 f+1
4 f+2
5 f+0
6 f+3

FIG. 5

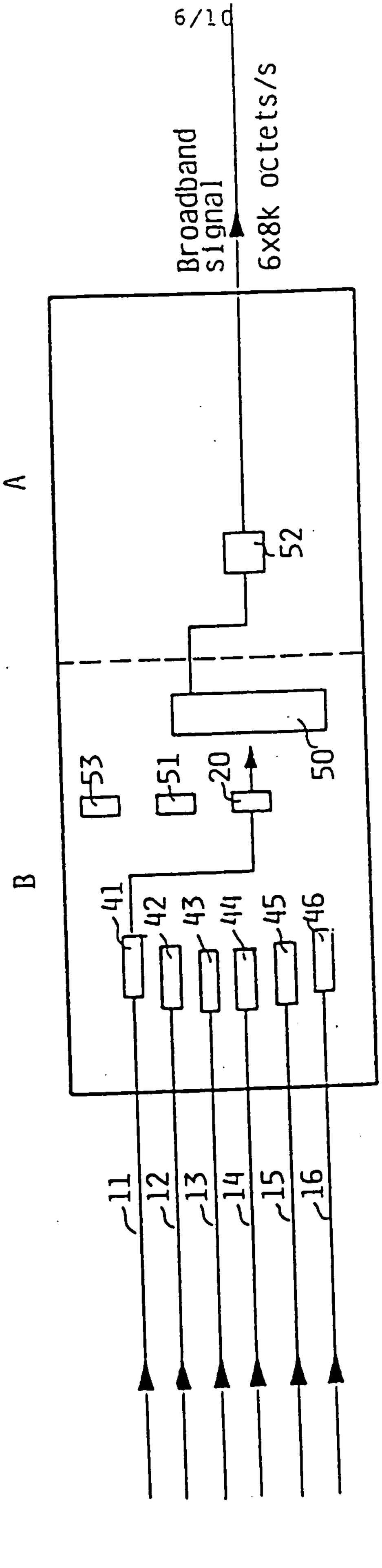
Broadband signal
6x8k octets/s
A
B
52
50
53
51
20
41
42
43
44
45
46
11
12
13
14
15
16

FIG. 6

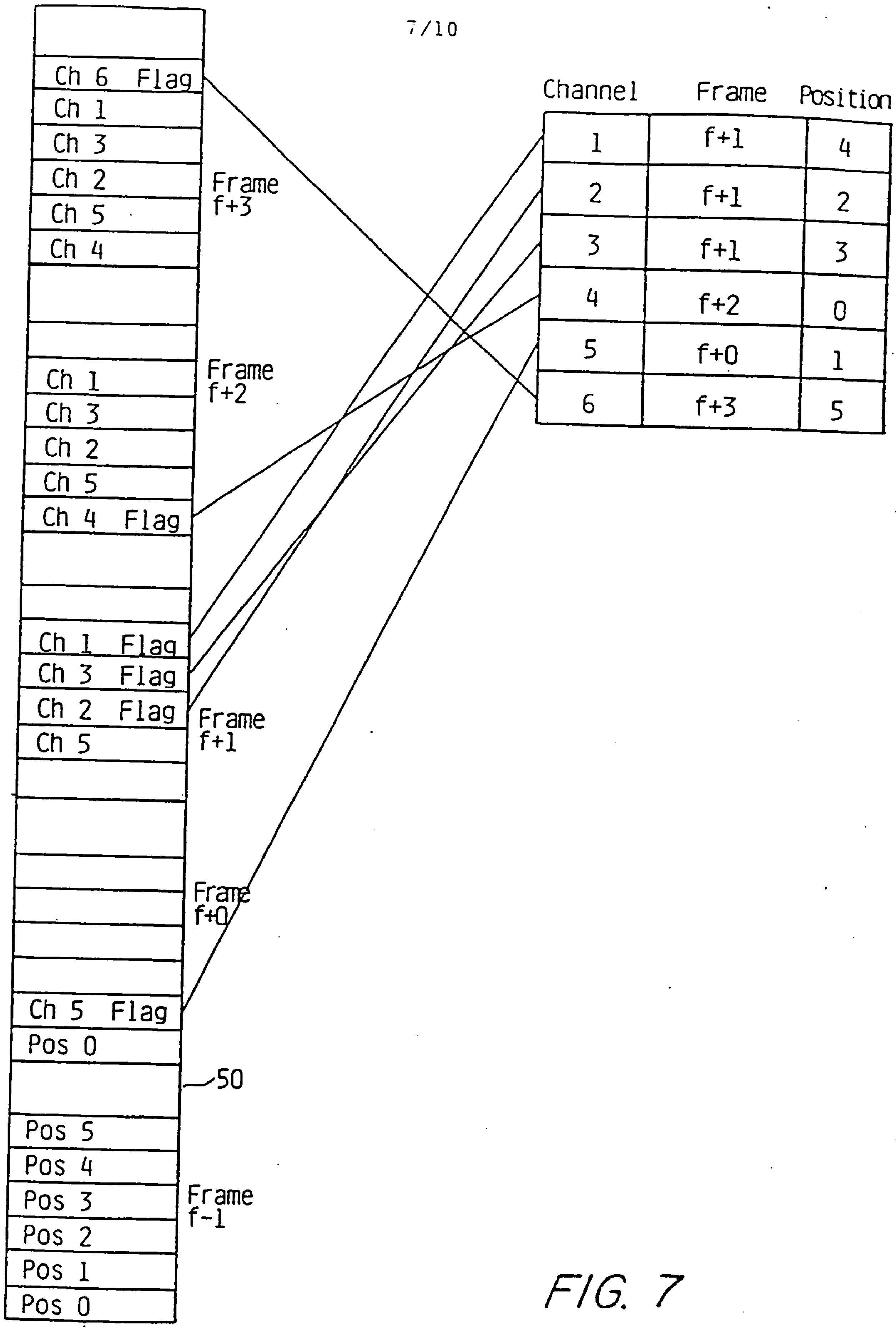
Ch 6 Flag
Ch 1
Ch 3
Ch 2
Ch 5
Ch 4
Frame f+3
Ch 1
Ch 3
Ch 2
Ch 5
Ch 4 Flag
Frame f+2
Ch 1 Flag
Ch 3 Flag
Ch 2 Flag
Ch 5
Frame f+1
Frame f+0
Ch 5 Flag
Pos 0
50
Pos 5
Pos 4
Pos 3
Pos 2
Pos 1
Pos 0
Frame f-1
Channel
Frame
Position
1
f+1
4
2
f+1
2
3
f+1
3
4
f+2
0
5
f+0
1
6
f+3
5

FIG. 7

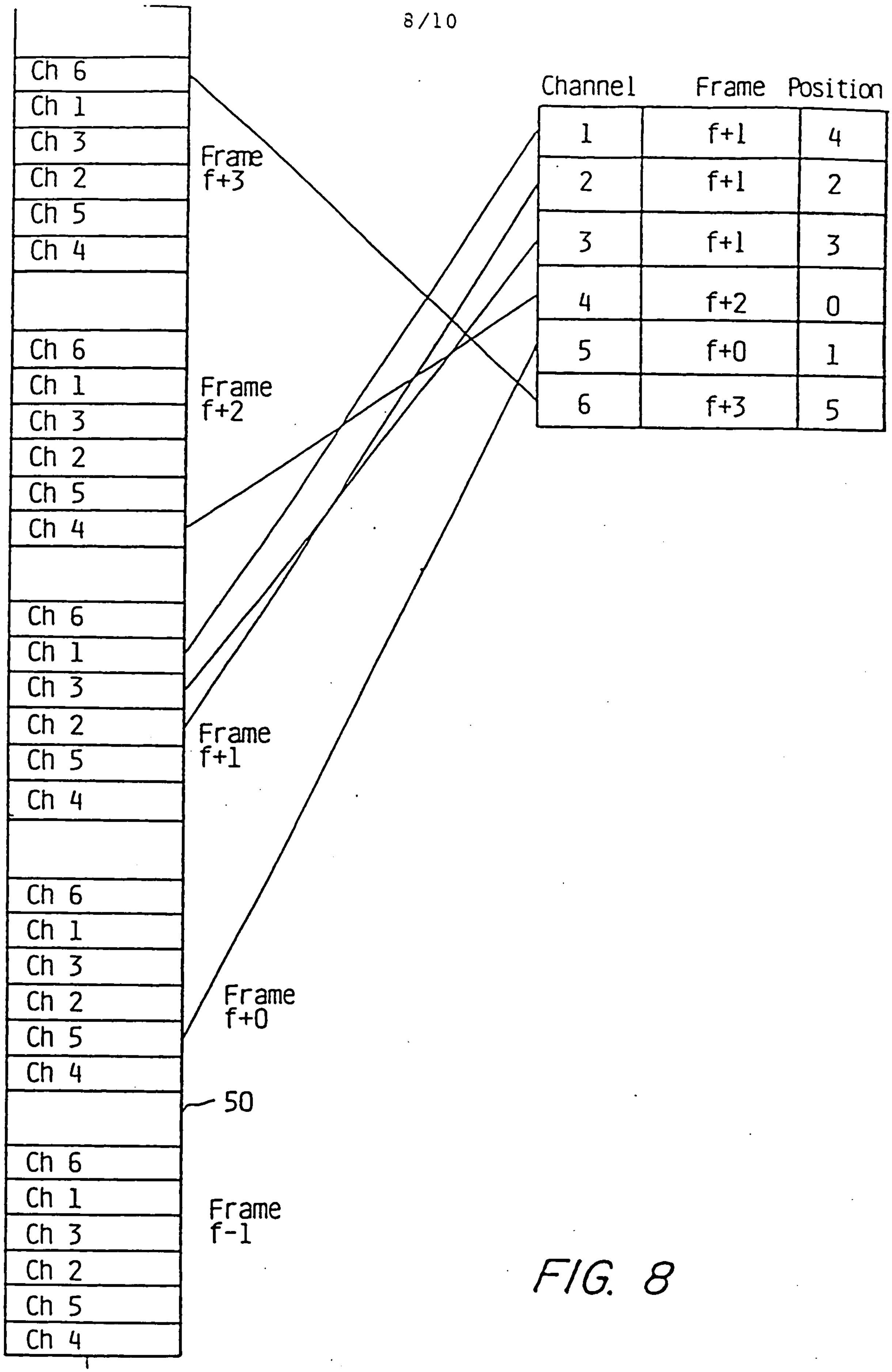
Ch 6
Ch 1
Ch 3
Ch 2
Ch 5
Ch 4
Frame f+3
Frame f+2
Frame f+1
Frame f+0
50
Frame f-1
Channel
Frame
Position
1
f+1
4
2
f+1
2
3
f+1
3
4
f+2
0
5
f+0
1
6
f+3
5

FIG. 8

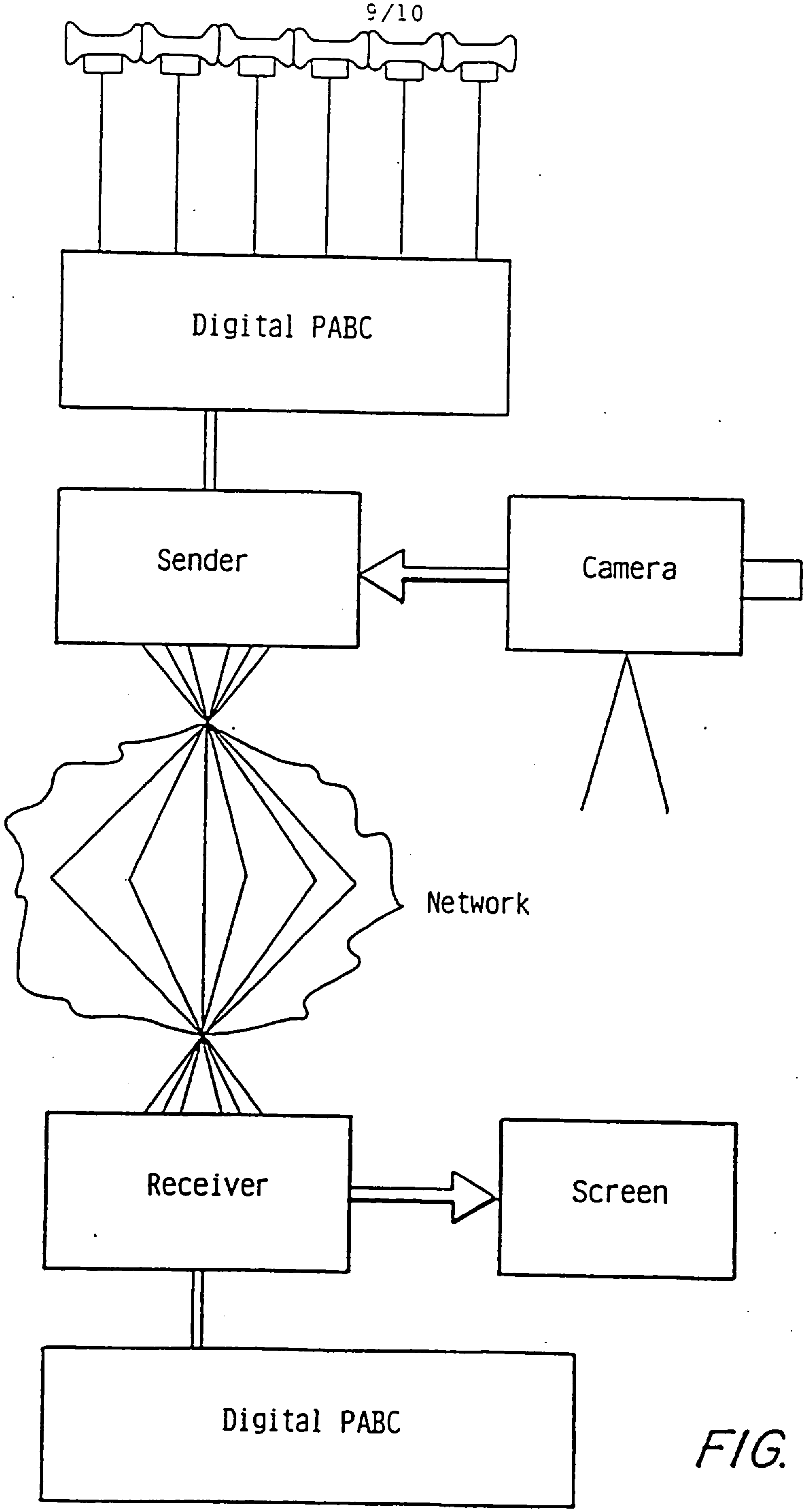
Digital PABC
Sender
Camera
Network
Receiver
Screen
Digital PABC

FIG. 9

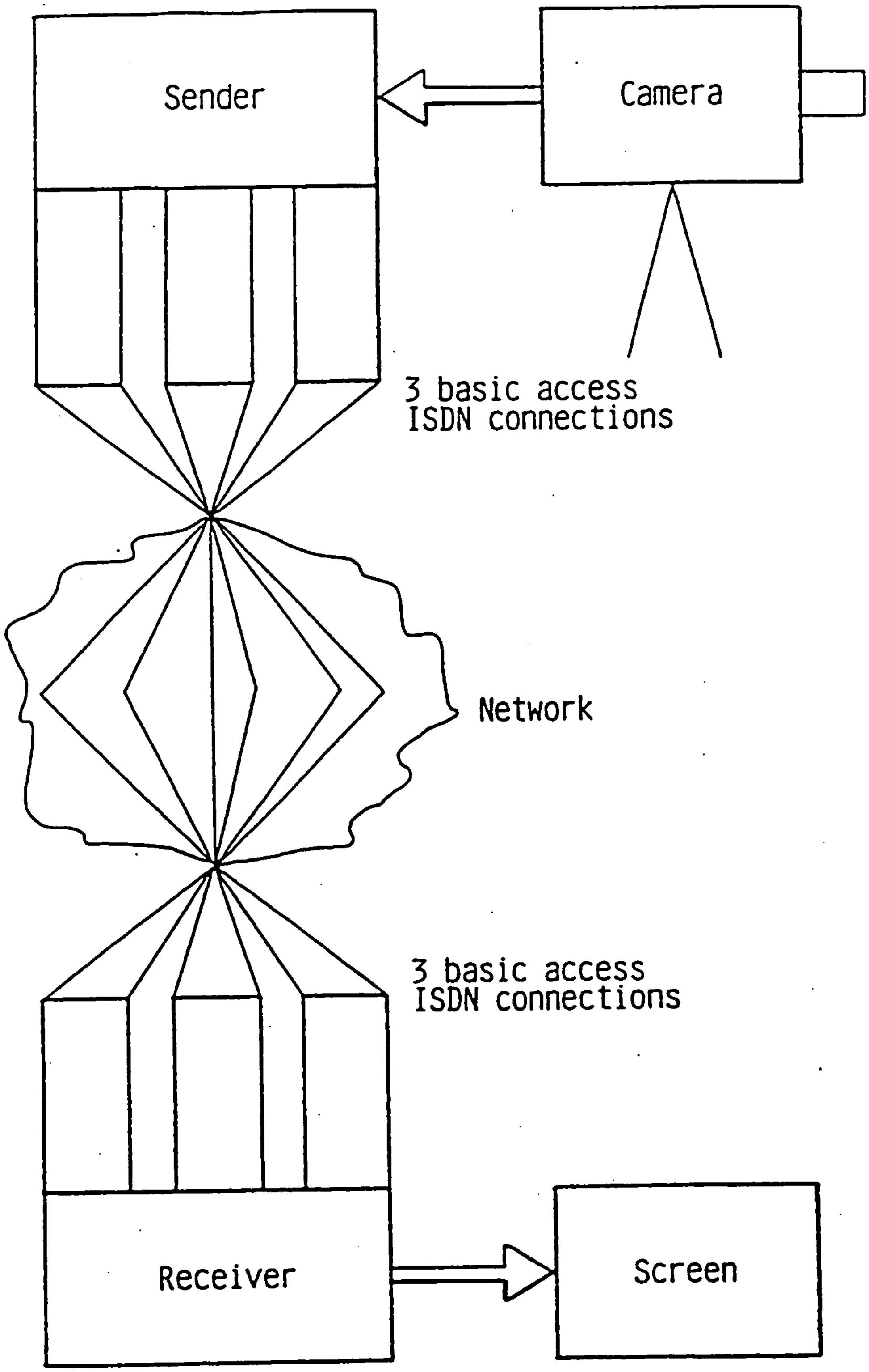
Sender
Camera
3 basic access
ISDN connections
Network
3 basic access
ISDN connections
Receiver
Screen

FIG. 10

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 90/00087

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: H 04 L 25/14

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	H 04 B, H 04 J, H 04 L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
A	US, A, 4775987 (MILLER) 4 October 1988, see column 2, line 61 - column 5, line 46; figure 2 --	1-6
A	US, A, 4630286 (BETTS) 16 December 1986, see column 2, line 18 - column 3, line 50 --	1-6
A	GB, A, 2074420 (WESTERN ELECTRIC COMPANY INCORPORATED) 28 October 1981, see abstract --	1-6
A	US, A, 4615040 (MOJOLI ET AL) 30 September 1986, see abstract --	1-6

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
31st July 1990	1990 -08- 0 1
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	RUNE BENGTSSON Rune Bengtsson

Form PCT/ISA/210 (second sheet) (January 1985)

SUBSTITUTE SHEET

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/DK 90/00087

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 90-06-27
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4775987	88-10-04	AU-B- 575635	88-08-04
		AU-D- 4113585	85-10-11
		EP-A-B- 0159810	85-10-30
		JP-T- 61501543	86-07-24
		WO-A- 85/04300	85-09-26
US-A- 4630286	86-12-16	NONE	
GB-A- 2074420	81-10-28	CA-A- 1160776	84-01-17
		DE-A- 3114066	82-02-25
		FR-A- 2480538	81-10-16
		JP-A- 56161759	81-12-12
		NL-A- 8101812	81-11-02
		SE-B- 459219	89-06-12
		SE-A- 8102113	81-10-15
		US-A- 4383316	83-05-10
US-A- 4615040	86-09-30	EP-A- 0164749	85-12-18

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